Multiple responses analysis and modeling of Fenton process for treatment of high strength landfill leachate

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ABSTRACT

Landfill leachate is one of the most recalcitrant wastes for biotreatment and can be considered a potential source of contamination to surface and groundwater ecosystems. In the present study, Fenton oxidation was employed for degradation of stabilized landfill leachate. Response surface methodology was applied to analyze, model and optimize the process parameters, i.e. pH and reaction time as well as the initial concentrations of hydrogen peroxide and ferrous ion. Analysis of variance showed that good coefficients of determination were obtained ($R^2 > 0.99$), thus ensuring satisfactory agreement of the second-order regression model with the experimental data. The results indicated that, pH and its quadratic effects were the main factors influencing Fenton oxidation. Furthermore, antagonistic effects between pH and other variables were observed. The optimum H_2O_2 concentration, Fe(II) concentration, pH and reaction time were 0.033 mol/L, 0.011 mol/L, 3 and 145 min, respectively, with 58.3% COD, 79.0% color and 82.1% iron removals.

Key words | advanced oxidation processes, fenton, response surface methodology, semi-aerobic landfill leachate

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INTRODUCTION

Landfill leachate is generally considered a potential source of contamination to surface and groundwater due to its organic and inorganic contents. Leachate characteristics are strongly dependent on the age of landfill and composition of the wastes (Lopez *et al.* 2004). Although biological treatments are universally used for the treatment of landfill leachates, they are usually insufficient in degrading high molecular weight fractions. Mature leachates with their low BOD/COD ratio (low biodegradability) are particularly difficult to treat by biological process. Therefore additional physico-chemical processes are needed for pre- or post-treatment of leachate (Tauchert *et al.* 2006). Recently, advanced oxidation processes (AOPs), have received great attention as an alternative method for reducing the organic load of landfill leachate. These methods are capable of transforming non-biodegradable pollutants into non toxic substances (Catalkaya & Kargi 2007).

AOPs use hydroxyl radicals ($OH^•$) as the oxidizing agent to non-selectively oxidize a wide range of biorefractory organic pollutants (Lucas *et al.* 2007). Amongst the AOPs, Fenton reagent has been increasingly used for the treatment of landfill leachate and recalcitrant compounds (Deng & Englehardt 2006; Kochany & Lipczynska-Kochany 2009).

Fenton oxidation can be described as a process that is based on the hydrogen peroxide decomposition in acid medium, catalyzed by ferrous ion to produce hydroxyl radicals (Mohajeri *et al.* 2010a). The process is complicated, with numerous parallel reactions, but could be briefly represented by the following reaction:

$$Fe^{2+} + H_2O_2 \rightarrow Fe^{3+} + OH^- + OH^• \quad (1)$$

Hydroxyl radicals produced during Fenton's reactions react with the pollutants to oxidize and break organic molecules, leading to mineralization of the organics to produce

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